PHOTOSYNTHETIC CHANGES OF "*PRUNUS AVIUM* L." GRAFTED ON DIFFERENT ROOTSTOCKS IN RELATION TO MINERAL DEFICIENCIES.

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Abstract

The performance of three different rootstock (Adara (*Prunus cerasifera* L.), SL 64 (*Prunus mahaleb*), and Colt (*Prunus avium* x *Prunus pseudocerasus*)) as nutrient suppliers has been studied for sweet cherry cultivars (*Prunus avium* L.). The results obtained suggested that, depending on the rootstock, the trees are submitted to different degrees of stress. According to the data obtained, it could be expected a different photosynthetic pattern of these trees for the same sweet cherry cultivar. Fluorescence measurements as well as photosynthetic pigment composition has been assessed to know the photosynthetic capacity of the trees. The highest Fv/Fm ratio was found in leaves from trees grafted over the rootstock Adara. An increase of the zeaxanthin (Z) content could be observed in the less adequate rootstock variety.

Key Index words : Fluorescence measurements, *Prunus avium* L., VAZ cycle, zeaxanthin content

1. Introduction

It has been known for many years that water stress reduces plant absorption of inorganic nutrients. In this way, different root configuration can play an important role in water and nutrient uptake, and influence soil management practices. The studied rootstocks (Adara, SL 64, and Colt) are commonly grafted with sweet cherry cultivars in Spain and other Mediterranean countries. Adara is a plum rootstock developed at the Estación Experimental de Aula Dei, Zaragoza (Spain), for use as an invigorating rootstock for different stone fruit species (Tabuenca *et al.*, 1988). Adara seems to be a suitable rootstock to avoid root asphyxia in heavy soils and/or under flood irrigation conditions where other rootstocks fail to survive.

Mineral deficiencies are often present in sweet cherry cultivars. More of these deficiencies modify directly pigment composition, for example iron or manganese deficiencies induced changes in pigment composition (Madero *et al.*, 1993; Pérez *et al.*, 1993, Val *et al.*, 1995). Nutrient limitations can also restrict plant biomass accumulation by either reducing the partitioning of assimilate to photosynthetic surface (leaf area growth) or by reducing photosynthetic rate per area. In some plants phosphorus limitation affects biomass partitioning and carbohydrate allocation (Madhusudana *et al.*, 1993). Mineral deficiencies are also associated with changes in photosynthesis by decreasing the efficiency of photosynthetic energy conversion. Changes in leaf photosynthetic parameters may be used to screen stress-resistant cultivars (Havaux *et al.*, 1888). Much evidence has now been accumulated supporting the involvement of the xanthophyll cycle (VAZ cycle) in the dissipation of excess excitation energy from photosystem II. Zeaxanthin concentration in leaves increases when light intensity is higher than that used by the photosynthetic apparatus.

During the past several years the performance of different rootstock for sweet cherry cultivars have been studied (Moreno *et al.*, 1996). Leaf mineral element concentrations were determined in the 12th year after planting, data demonstrated different nutrient composition among leaves of the same variety grafted over different rootstocks (Moreno *et al.,* 1996). In this work we analyse several physiological parameters to test which is the most suitable rootstock on calcareous soils. A 13 years old cultivar is analysed to determinate the influence of rootstocks in the performance of the photosystem II in leaves from trees with different mineral contents. Fluorescence and pigment composition are the techniques that allow us to carry out this study.

2. Material and Methods

2.1 Plant material

The orchard was located at the Estación Experimental de Aula Dei on calcareous soil. Sweet cherry cultivars (*Prunus avium* L.) were grafted on three different rootstocks (Adara (*Prunus cerasifera* L.), SL 64 (*Prunus mah*al*eb*), and Colt (*Prunus avium* x *Prunus pseudocerasus*)). Leaves for analysis were collected 30 days after full bloom, when fully developed. Samples were taken in six different trees per each rootstock.

2.2 HPLC pigment determination

Photosynthetic pigments were extracted from 5 leaf discs of known area (0.4 cm^2) These discs were removed from leaves and immediately submerged in liquid nitrogen. Extraction of pigments and analysis of the extracts by HPLC were as described in Val *et al*., (1994).

2.3 Fluorescence measurements

Non-destructive chlorophyll fluorescence measurements were performed in attached leaves using a field-portable fluorescence system (Photosynthesis Efficiency Analyser, -PEA- Hansatech). Leaves were selected and dark adapted for 30 min prior to the estimation of fluorescence parameters.

In brief, PEA is able to determinate some parameters of the chlorophyll fluorescence induction by illuminating with a focused array of ultra-bright red LEDs that supplies a wavelength of 650 nm (intensity up to 3000 $\mu mol/m^2/s$, 1000 $\mu mol/m^2/s$ in our case). The emitted fluorescence is detected by a PIN photodiode and fast detection circuit protected by long-pass infra-red photographic filter.

3. Results

Previous work performed on the same trees by Moreno *et al*., (1996) indicated a different leaf mineral composition depending on the rootstock. N, K and Mn concentration were higher in the leaves from the trees grafted over Adara. Concomitantly leaf yellowness was observed in the trees grafted over SL 64 and Colt. These symptoms were also observed during the season of actual experiments.

Chlorophyll fluorescence parameters were differently influenced in the studied trees. Fo was not affected by the rootstock but the ratio Fv/Fm was higher in trees grafted over Adara. This suggests that trees grafted in the other rootstocks have a decreased efficiency in the conversion of photosynthetic energy under high light in the field (Table 1)

Table 1. Fluorescence parameters and total VAZ content (mean ± 1SE).

	Rootstock		
	Adara	SL 64	Colt
VAZ (μg/cm^2)	5.46 ± 0.357	4.65 ± 0.408	4.13 ± 0.365
Fo	0.25 ± 0.006	0.26 ± 0.009	0.25 ± 0.007
Fm	0.94 ± 0.046	0.96± 0.016	1.05 ± 0.027
Fv/Fm	0.76 ± 0.003	0.72 ± 0.023	0.73 ± 0.007

The analysis revealed significant differences for all the pigment studied. Trees grafted over Adara shown higher concentration for most pigment studied than those grafted over the other rootstocks (Table 2); only the leaf concentration of antheraxanthin (A) and zeaxanthin (Z) decreases (Fig. 1), which seems to indicate a relatively low capacity to perform photosynthesis for trees grafted on Colt and SL 64. The ratio Chl a/b seems to be constant in all trees, but total chlorophyll was higher in Adara.

Table 2. Photosynthetic pigment composition of leaves from the different studied trees.

	Neoxanthin	Violaxanthin	Antheraxanthin	Lutein	Zeaxanthin	Chl b	Chl a	ß-Carotene
Adara	2.39	1.43	1.27	6.17	2.76	11.00	36.66	5.43
Colt	1.53	0.52	0.85	4.37	2.75	7.25	25.30	3.73
SL 64	1.55	0.54	0.90	4.88	3.22	7.28	24.65	3.54

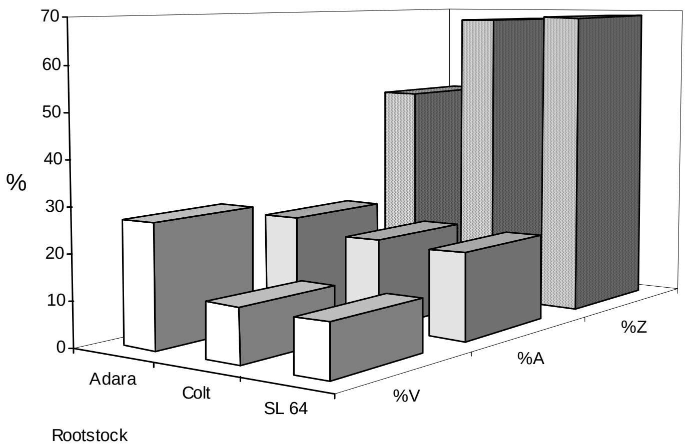

Figure 1. Leaf VAZ cycle pigment composition in the three rootstock analyzed.

4. Discussion

The three rootstocks studied previously showed different suitability for cherry cultivars (Moreno *et al*., 1996). Such different pattern induced less efficiency in terms of nutrient uptake for SL 64 and Colt trees which are evident attending the visual symptoms (yellowness), developed by the leaves attached to these trees, and also their lower chlorophyll concentration (Table 2). Furthermore, mineral analysis performed over the same trees the previous season (Moreno *et al.*, 1996), indicated the possibility of some mineral deficiencies. Mineral deficiencies are often linked to changes in photochemical activity. Changes in fluorescence and pigment composition reflect the different suitability of these rootstocks in our work conditions.

The same variety grafted over three different rootstocks has shown different photosynthetic capacity. Fo level was not significantly different for the studied trees, but the Fv/Fm ratio slightly increases in trees grafted over Adara. On the other hand, the level of zeaxanthin increases in the same samples. This fact seems to indicate the increase of the non-photochemical quenching that support the involvement of pigments within the xanthophyll cycle in photoprotective mechanisms. (Morales *et al*., 1994).

When the input of high light exceeds the capacity for energy utilization, the light-induced displacement of the VAZ cycle towards de-epoxidation (i.e. formation of one molecule of zeaxanthin per molecule of Chl a) has recently been shown to be paralleled to decreases in the fluorescence yield. In plants affected by several environmental stresses, changes in Fv/Fm ratios together with changes within the xanthophyll cycle have been reported (Demmig-Adams *et al*., 1992). The energy dissipation process, associated with the de-epoxided components of the xanthophyll cycle was accompanied by the conversion of the majority of the xanthophyll cycle into zeaxanthin and antheraxanthin.

As a conclusion it can be stated that, the VAZ cycle composition, especially in Adara (the lowest zeaxanthin content), and the fluorescence measurements (the highest Fv/Fm ratio) agree with the expected enhanced nutrient uptake capacity, as was previously described for this cultivar (Moreno *et al.*, 1996).

All these data allow us to conclude that the performance of these rootstocks could be easily studied by photosynthetic measurements.

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